Peer Review Comments on EPA's Draft Document,
An Assessment of Potential Mining Impacts on Salmon Ecosystems of Bristol Bay, Alaska

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I. GENERAL IMPRESSIONS

The purpose of the document is not clearly stated, either in the Executive Summary or the Introduction. Need to specifically identify the document as an environmental risk assessment. There is a misconception that it is a CWA Section 404(c) review, rather than an environmental risk assessment. The document should have the utility to inform future users of the risk to the watershed resources from mining activities in the watershed. The assessment can be used by others for decision making purposes, and includes current and appropriate methodologies for all identified stressors, such that study results can be duplicated. And all stressors are evaluated to a similar level of detail.

The document characterizes the potential environmental effects of an open pit mine over a copper porphyry complex in southwest Alaska using a hypothetical mine design based on similar ore deposits and mine complexes elsewhere. Proposed mine activity has been identified by the Pebble Limited Partnership though Northern Minerals Dynasty and should be cited to improve applicability of the risk assessment. Furthermore, a wider range of mining scenarios should be developed and analyzed for environmental risk assessment. Environmental consequences were estimated by the environmental risk assessment model approach for both 'no failure' and 'failure' scenarios. The Executive Summary concluded that the effects of mine development resulted in significant salmon habitat losses. Potential effects on other aquatic species were not identified. The assessment evaluated environmental risks under the development and closure scenarios using large catastrophic events and did not include smaller, yet more frequent excursions or system failures. Nor did the assessment look at the full range of mine development scenarios, specifically what are the risks associated with a smaller underground operation?

The conclusions of the Executive Summary are strongly worded (e.g. pp. ES 13-24) yet the uncertainties presented later in the report make the strong conclusions tenuous. An expanded discussion of uncertainties and limitations may temper those 'conclusions'.

Site characterization/description of current conditions is too brief. More information is needed for a full site characterization. Any reader unfamiliar with the setting would not fully understand the physical, biological, or ecological inventories and linkages in the study area. The risk assessment of failure and no failure are covered in Chapters 5 and 6 with varying levels of detail and substantiation of conclusions. Statements like salmon is important in the human diet, thus a salmon loss affects human health seems like a weak argument, especially when additional information in the appendix suggest a larger effect.

The Pebble Limited Partnership has a large environmental baseline database (EBD) but does not appear to be cited or used. Justification for the inclusion or exclusion of these data should be made. Reference is often made to various data, but these data were not presented.

Review and revise the water-balance, which would include: 1) generating a diagram or conceptual figure similar to page 3-7 to illustrate the potential effects of mine construction and operation on surface and groundwater hydrology ; 2) develop a quantitative water balance for surface and groundwater resources; 3) incorporating seasonality (especially assessing the role of frozen soil); 4) identify hydrologic processes and their associated values (mm/yr etc) for each component of the water balance in time and space, and then incorporate into a landscape characterization; 5) demonstrate the interconnectedness of groundwater, surface water, and the importance to fish habitat and stream productivity; 6) evaluate the influence of global climate change on these hydrologic processes and rates; 7) then using this characterization demonstrate the expected hydrologic modification associated with the mine scenarios and infrastructure development and closure scenarios.

One common theme that emerged from the public scoping session in Anchorage was the questioning of the document timing, from draft release, public comment period, to the unannounced completion of a final document. These concerns should be addressed to increase in the new document.

II. RESPONSE TO CHARGE QUESTIONS

1) ***The EPA's assessment focused on identifying the impacts of potential future large-scale mining to the fish habitat and populations in these watersheds. The assessment brought together information to characterize the ecological, geological, and cultural resources of the Nushagak and Kvichak watersheds. Did this characterization provide appropriate background information for the assessment? Was this characterization accurate? Were any significant literature, reports, or data missed that would be useful to complete this characterization, and if so what are they?***

The site characterization needs to be expanded. The report needs to better characterize the physical setting. There are a variety of data sources that can be used to better describe the physical setting. It would be useful to see geology, geomorphology, soils, vegetation, digital elevation maps, hypsometric curves of the watersheds in question, streamflow data, precipitation data—especially storm events, and water quality data for surface and groundwater over time and space. Various geographical information system maps would be useful here.

The salmon populations and habitat linkage needs to be better documented, since many of the mine impacts are resulted from hydrologic modification. Figures 3-2A to E represents good thinking and an understanding of the linkages and potential effects of mining on these resources. The linkages to indigenous peoples is illustrated in Figure 3-2E, but little text is presented, referring the reader to the Appendix. The other conceptual models are not adequately addressed in the text. These flow charts present an opportunity to present processes and linkages as related to potential effects of mine development activity and need to be developed within the text. Indeed, they seem to stand alone with little discussion of potential effects. Not all charts have adequate materials in the appendix for coverage, thus the variability in resource coverage is inconsistent and infers either a writing bias or data (lack of) bias.

The assessment concludes that a hydrologic modification will have detrimental salmon habitat consequences. The groundwater contributions to streamflows are important, both hydrologically and ecologically. Additional streamflow and groundwater data are needed to represent this linkage. Similarly, additional water quality data over time and space and include water hardness for metal standards. Depth to groundwater as related to streamflow, age dating of waters, streamflow modeling would all be useful to illustrate the groundwater upwelling and hyporheic exchanges.

Site disturbance will be significant, yet no discussion of soil erosion. Soil erosion and subsequent suspended sediment transport would have the potential to have significant effects on water quality, channel delivery efficiency, salmon, salmon habitat, and metal transport. There is a generic discussion of road construction related erosion, but road standards, road location, road usage, road maintenance (salting, grading, or watering), length of roads would help in the risk assessment.

Are any endangered or threatened species present, either state or federally listed?

2) ***A formal mine plan or application is not available for the porphyry copper deposits in the Bristol Bay watershed. EPA developed a hypothetical mine scenario for its risk assessment, based largely on a plan published by Northern Dynasty Minerals. Given the type and location of copper deposits in the watershed, was this hypothetical mine scenario realistic and sufficient for the assessment? Has EPA appropriately bounded the magnitude of potential mine activities with the minimum and maximum mine sizes used in the scenario? Are there significant literature, reports, or data not referenced that would be useful to refine the mine scenario, and if so what are they?***

The document does not adequately bound the range of mine scenarios. The minimum mine development scenario is not adequately addressed. A frequent criticism in the public sessions was that mine plans presented in the assessment are not representative of current standards. A *compilation* of existing world porphyry mine complexes as well as other types of mines specific to Alaska would better inform the reader of mining processes and potential risks. The physical setting in Southwest Alaska is not the same as Bingham Mine in Salt Lake City. Currently the document refers to a particular mine in a particular risk assessment (stressor). i.e. Fraser River for salmon, Aitika for chemistry, Altiplano for pipeline failures.

The Bureau of Land Management has identifies certain lands that will be excluded from development. This reference needs to be followed up.

3) ***EPA assumed two potential modes for mining operations: a no-failure mode of operation and a mode involving one or more types of failures. Is the no-failure mode of operation adequately described? Are engineering and mitigation practices sufficiently detailed, reasonable, and consistent? Are significant literature, reports, or data not referenced that would be useful to refine these scenarios, and if so what are they?***

The no-failure mode is not adequately described. Assessment of the effects of the mine is based on large risk failures of low probability and did not include low risk failures of higher probability. The report concludes (and emphasizes) that the mine footprint will disrupt/disturb contributing watershed areas and wetland areas and result in hydrologic modification and the hydrologic modification affect salmonid habitats, particularly in low flow conditions. Regulatory oversight will include the State of Alaska, and certainly mitigation measures would be required. The task is to address the adequacy of these mitigation measures.

Pollutant/toxicity assessment focused on copper. Other metals can be presented to show the range of metal concentrations for chronic and acute toxicity. Suitability of treatment processes for all wastewaters can be included to address potential effects on receiving waters.

The discussion of roads is mostly related to fish blockage and some soil erosion. Information on current design standards was not included and tended to relay on dated references from logging roads.

There were no engineering or mitigation practices described in this section or in the document..

4) ***Are the potential risks to salmonid fish due to habitat loss and modification and changes in hydrology and water quality appropriately characterized and described for the no-failure mode of operation? Does the assessment appropriately describe the scale and extent of risks to salmonid fish due to operation of a transportation corridor under the no-failure mode of operation?***

To address this question a water balance needs to be developed for the study area watersheds. Develop a water balance that includes all the principal components and how they may vary in time and space. The site characterization needs significant improvement, particularly as related to hydrologic inventories and processes. Little to no data are presented on temperature, precipitation, evaporation, frozen soils, soil moisture storage, groundwater storage and movements. What data that are presented often have unreasonable significant figures. The linkage between surface and groundwater needs to be better demonstrated. Hyporheic exchanges are recognized as being important, but the assessment does not demonstrate this linkage.

Iliamna Lake hydrology needs to be characterized. What are the inflows, outflows, and turnover rates? What is the existing water quality in the lake? Aquatic life should be characterized as well. What is the risk of pollutants entering the lake from the road corridor or upstream mine development operations?

Climate variability is recognized as a game changer. What are the potential future scenarios for southwest Alaska for temperature and precipitation changes, and how will these scenarios affect the water balance? How will climate change affect the availability of water for mine operations including processing and potable uses?

Similarly a complete water quality characterization is lacking. What is the water quality in surface waters, groundwaters, in time, and in space? What is the definition of background water quality? Numerous exploratory activities have taken place in the watershed and have the potential to affect water resources. How were these separated or addressed? Given the geologic and geomorphologic settings for the study area are we comfortable that the watershed ridges delineate the watershed area? Groundwater movements may ignore the physical watershed area boundary and follow groundwater gradients. Streamflow measurements from the gauged watersheds could be useful in answering this question. Similarly, the linkage of groundwater and hyporheic exchange needs to be better demonstrated. Do these exchanges occur in all stream segments and gradients? What effect does the groundwater have on stream temperatures? Are depth to groundwater readings available? Is a groundwater monitoring program in place?

The tables and hydrographs (5-32 to 5-39) are unclear. What streamflow changes are associated with what salmon species and life stage? A boundary condition for adults is different than for fry.

The proposed mine will use large quantities of water in ore processing and transport. How much is required and how will this affect water resources; both surface and groundwater? The no-failure mode of operation is predicted to change the watershed contributing area and hence streamflow, and uses the boundary condition of a 20% change in streamflow as significant salmonid habitat loss. The assessment assumes a liner response between watershed area and streamflow contribution, and a linear response between habitat productivity and watershed area. Upland settings are probably more productive in terms of productivity and should be addressed as such. Toxin assessment focused on copper, and other metals can be presented to show the range of metal concentrations for chronic and acute toxicity i.e. arsenic, molybdenum, silver, barium, and lead. Given the very clean waters (low hardness and organic carbon), the chronic toxicity of various metals should be evaluated. Water quality varies in time and space in the study area, and a better characterization of water quality could be developed. With streamflow records metal loads could be calculated. What is the proportioning of dissolved versus total metals? Are metals transported with sediments? Do organic carbon fluxes change in space or time?

Specific water quality treatment processes were not identified for the intercepted tailings groundwater, slurry water, or other mine activity processing waters. The removal of copper from low hardness waters is different than the removal of zinc. A treatability study of all mine drainage waters should be included.

Salmonid risk from travel corridor. The proposed road location has the potential to affect 270km of stream between stream crossings and Lake Iliamna. The expected road erosion and sediment production has known affects on salmonid resources. The discussion of the travel corridor does not include the potential for road failures, landslides, blocked culverts, ditch failure. The discussion does not talk about traffic volume or the potential of hazardous material transport on the travel corridor. Need to address road maintenance, fugitive road dust, road chemicals either dust or ice control.

There is no discussion of water processing after delivery of the slurry to the sea port and return of waters back to the mine site.

5) ***Do the failures outlined in the assessment reasonably represent potential system failures that could occur at a mine of the type and size outlined in the mine scenario? Is there a significant type of failure that is not described? Are the probabilities and risks of failures estimated appropriately? Is appropriate information from existing mines used to identify and estimate types and specific failure risks? If not, which existing mines might be relevant for estimating potential mining activities in the Bristol Bay watershed?***

The assessment reasonably addresses potential large system failures, but should include a variety of smaller and perhaps more frequent failures (see Question 4). A large tailings storage facility failure compared to a blocked road drainage culvert. The level of detail in the assessment of the potential system failures varies considerably and baits the question--why? Does this demonstrate lack of understanding of failure prediction, lack of failure prediction, or writing team expertise?

Tailings storage facility. The liquefaction phenomenon, internal and external erosion, seepage and overtopping are some of the main failure modes of tailings storage facilities. A large quantity of stored water is the primary factor contributing to most tailings storage failures. The risk of physical instability for a conventional tailings facility can be reduced by having good drainage and little (if any) ponded water. Some suggest that the tailing pond freeboard should be able to accommodate the 100-year 72-hour storm/streamflow event. What are the State of Alaska standards? Discuss the probability of failure of a TSF from other than overtopping by a precipitation/streamflow event. The potential of seismic activity and its effect on tailings storage and other earthworks needs to be addressed.

Chemical transport spill. Mine development and ore processing will require significant loads of petroleum and chemical products. Although the exact processing formulations not given, most copper porphyry mines use similar formulation in ore flotation and processing. How will chemicals be stored, transported, recycled. What opportunities for accidents to occur?

6) ***Does the assessment appropriately characterize risks to salmonid fish due to a potential failure of water and leachate collection and treatment from the mine site? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

The tailings storage facility (TSF) is designed to hold the tailings under water to minimize the oxidation of pyritic materials and limit ARD or AMD production. The TSF will be underlain by hypalon to capture leakage waters. There is the possibility of failure to collect waters from the TSF—either surface runoff or leakage with or without storm (precipitation) events. There is the possibility of failure of the treatment plant to treat the wastewater. Such treatment systems in Colorado usually have a bypass pond to temporarily hold waters for later pump back and treatment as a result of power failure, plant going off-line, storm events, or plant maintenance.

The waters in the study area have very low buffering capacity and metal toxicity would occur at low concentrations and dilution of metals would require time and space. The maximum index counts on page 6-39 are confusing and not well related to the risk characterization. Copper was used as an example metal, but other metals are also toxic and further characterization of the waste rock can be presented. Further analysis of a water and leachate collection failure can be made over time: the effects of dilution flows over the various months with low flows or when adult salmon are present in the stream as opposed to juveniles. Or when juveniles are emerging. The toxicity quantification is difficult and appears more of an academic exercise here, rather than site specific.

Leachate collection from the tailings area is only briefly described. What are the State of Alaska standards for collection and treatment? What are the potential effects of not collecting or treating the tailings leachate waters? Compare the detail and length of leachate discussion to the TSF failure discussion (see earlier comments).

Given the hydrologic connection between surface and groundwaters, what effect will interception of all waters on the TSF do to surrounding wetlands and groundwater levels. Again the lack of a water balance does not let the reader determine if this water interception is significant or will have significant resource effects.

Most, if not all of these failures are the result of human error. What safeguards will be in place? What are the best mining practices to minimize human error?

7) ***Does the assessment appropriately characterize risks to salmonid fish due to culvert failures along the transportation corridor? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

No. Unclear how the estimate of 50% of the culverts would fail, given the literature shows a range of 30 to 60% (Section 4.4.4). What literature was used? Are road BMPs satisfactory in this environment? Have the Alaska BMPs been audited? Culvert repair taking a week to several repairs in a month seems high. If the road crosses a critical salmon rearing stream, conservative pipe sizing or bridgework could be considered. The direct loss or inaccessibility of upstream salmon habitat does not necessarily translate to salmon loss. Timing of culvert blocking event with salmon migration and duration of blockage should be considered. Need to include references to Alaska Department of Natural Resources and Alaska Department of Transportation.

What are the design considerations for the culverts? What precipitation/streamflow relationships will be used for sizing purposes? What are the usual casual mechanisms fro culvert failure? How much woody material do these streams carry? Do culverts fail from debris plugging, road slumps, or overtopping by storm events? What road BMPs will be implemented?

8) ***Does the assessment appropriately characterize risks to salmonid fish due to pipeline failures? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

The pipeline corridor consists of 4 pipelines over a distance of 86 miles. No information was provided on pipeline structure or placement, other than mentioning of stream crossings. The pipeline failure of concentrate slurry was modeled using chemistry from the Aitik (Sweden) mine, is this best approximation? That mine is about 80 years old and is processing ore from the edge of the pit, with much lower sulfur content than Pebble.

Pipeline failures can be significant in any environment and spill or pipe break prevention requires significant monitoring. Will automatic shutoff controls be included? Workers are stationed 24 hours/day every day? Some of the past Alaska failures were in winter conditions, when things were not easily visible--under ice or snow cover. How will this be addressed?

The toxicity approach seems reasonable. What is the anticipated chemistry of the return waters? Diesel spill monitoring? The geometric mean of three values (which references) is that there is a 14% probability of failure in each pipeline in each year. This is not acceptable at any level.

9) ***Does the assessment appropriately characterize risks to salmonid fish due to a potential tailings dam failure? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?***

The tailings dam failure was modeled and distance of sediment transport estimated. The modeled tailings dam failure used an estimate of 20% mobilization from the tailings ponds. How was this value determined? The model was run to a stream length of 30km (the rivers confluence), yet the report acknowledges that a sediment pulse could run for 100s of km. The moisture content of the tailings is estimated to be 45% by volume (p. 4-50), the 20% volume of sediment may be underestimated. This initial risk to salmonid fish is clear, but the persistence of the sediment affect could be discussed.

The Mt. St Helens analogy is inappropriate for a variety of reasons and such comparisons should be removed from the assessment.

The PMP (probable maximum precipitation) value was extrapolated from Miller 1963 and the assessment commented how this value might be reduced upon further analysis. Conversely, additional data could increase this value. There was no discussion of the recurrence interval of this 24 hour storm.

No hydrologic data were provided. The streamflow gauging stations operated by the US Geological Survey near the study area, suggest peak streamflow rates from snow melt and from rain events. The hydrograph shape and magnitude help determine if rain or snowmelt dominated. In the assessment, the peak flow estimate from the NRCS runoff method used a Type 1a storm distribution, the least intense precipitation distribution, and the literature would suggest that a Type 1 distribution would be more appropriate for Alaska. How does this storm event compare to the measured flood at Ekwok (p. 4-50)? The curve number (CN) was not identified, nor the methods used to calculate that value. Similarly the watershed slope, time to peak, hydraulic length, channel routing functions, and channel resistance methods or results were not presented. What precipitation data are available? Design of culverts, bridges, storm water ponds, all require good precipitation records and the confidence in that estimate is based on record length.

The comparison is unclear for a 3313cms flow in a 2551 km^2 watershed area, to the TSF flow of 1862 cms and an area of 1.4 km^2. What was the precipitation and recurrence interval for the Ekwok storm? The relation of groundwater flows to streamflow during storm events needs to be evaluated. The flood producing precipitation events in this area no doubt add to groundwater flows.

With a new estimate of precipitation depth of known recurrence interval, the design storm could result in a higher flood event with greater velocities and greater sediment transport ability, with a greater sediment volume released from the TSF, resulting in a greater risk to salmonid fish and habitats.

10) Does the assessment appropriately characterize risks to wildlife and human cultures due to risks to fish? If not, what suggestions do you have for improving this part of the assessment? Are significant literature, reports, or data not referenced that would be useful to characterize these risks, and if so what are they?

The effect on wildlife section largely focuses on the return of nutrients to the land in various shapes and forms and adds little to the risk discussion. Other then marine derived nutrients, other stressors exist. What are the consequences of the mine operation on other wildlife habitats? Habitat fragmentation? Noise and light disruptions, etc?

Mine development will require the use of explosives. What are the effects of the nitrate and ammonia in the air following each detonation? The National Trends Network data suggest that the area receives about 1 kg/ha/yr of N in precipitation. Thus the increase in atmospheric inputs from the explosions may exceed the marine derived nutrients. What are the consequences?

The potential loss or change in life styles of indigenous peoples is important, but this information seems relegated to Appendix D. Include more of this information in the main body of the text. Actually there is a significant amount of information in the appendices that should be brought forward.

It is unclear why there is such variability in the detail or depth of assessment of each of the stressors. Why does the TSF failure have 34 pages and potential effects on native peoples a few pages with a reference to an appendix? The unevenness of the coverage needs to be addressed.

11) Does the assessment appropriately describe the potential for cumulative risks from multiple mines? If not, what suggestions do you have for improving this part of the assessment?

Cumulative risks can result from multiple risks (effects) from a single mine or individual risks from multiple mines. This chapter identified potential risks from proposed mine activities; without consideration of design standards or performance criteria, which is difficult without specific mine designs/plans. Environmental risks were weighted equally—a TSF failure as compared to a blocked culvert. The simple addition of stream-length as affected by various mine footprints does not represent a cumulative risk.

The assessment does not identify any past activities, which is doubtful even in SW Alaska, and does not define a baseline condition for which to compare many individual or cumulative risks. There are many factors that could be included in the cumulative effects analysis, from multiple mines. Human footprint of physical infrastructure: work camps, schools, community services, recreation, increased road access for visitors, sewage treatment facilities, urbanization effects on habitats and environment, transportation corridor, pipeline corridor, water resources usage, regional and global climate change.

12) Are there reasonable mitigation measures that would reduce or minimize the mining risks and impacts beyond those already described in the assessment? What are those measures and how should they be integrated into the assessment? Realizing that there are practical issues associated with implementation, what is the likelihood of success of those measures?

The purpose of this assessment is not to identify mitigation measures. This suggests that things can be fixed by mitigation. Risks were identified for a variety of situations, and the preventative measures would better address the mining impacts. Mitigation measures are also a mining cost that needs to be determined by the mining company and compliance with state and federal regulatory authorities.

13) Does the assessment identify and evaluate the uncertainties associated with the identified risks?

The uncertainties are presented adequately.

14) Are there any other comments concerning the assessment, which have not yet been addressed by the charge questions, which panel members would like to provide?

There are several references to streamflow measurements especially that would be helpful to better characterize the site. The US Geological Survey has some streamflow gauging stations and precipitation records that would complement the analysis. Annual precipitation values were derived apparently from a computer model used to analyze global climate change at UAF. How do these data compare to field measurements. The prediction of a 10, 50, 100, or larger event using a short-term precipitation record results in a larger error term on the predicted streamflow. How common is the occurrence of rain on snow (ROS) streamflow events?

Dust production and transport. A variety of mining processes will generate dust. What are the wind patterns, chemical composition and opportunity to land in surface waters or wetland areas? What potential is there for metal or toxin transport? Overburden removal will require explosives that leave nitrate, ammonia, and often sulfur in the air. What about this transport? Or rain out?

The literature cited is often dated or lacking. The technical review panel has proposed numerous references that can be used to strengthen the document.

III. SPECIFIC OBSERVATIONS

Provide any specific observations, corrections, or comments on the document, mentioning page, paragraph, and/or line number (expand table if needed).

Page	Paragraph or Line #	Comment or Question
ES-9		Economics of Ecological Resources –section seems weak
ES-14		Overall risk to salmon and other fish. Never really separate fish species out in other discussions. Dolly varden more sensitive to metals?
2-3	3	Four climate classes. Why this classification system? Perhaps easier to identify by watershed maps?
2-5		Precipitation values—significant figures?
2-23		Monthly values of streamflow. Would be nice to see average or daily streamflows somewhere.
3-7 -11		Would like to see more discussion of conceptual models. If a picture is worth a 1000 words……
4-1	1	………*reflect current good, but not necessarily best, mining practices*. Why not use the best methods or state of the art methods?
4-18		Shaded relief. Perhaps contour lines in another figure?
4-21	1	……..*most plausible sites given geotechnical, hydrologic, and environmental considerations*. Can this be elaborated?
4-21	2	…….*the TSF would be unlined other than on the upstream dam face and there would be no impermeable barrier constructed between tailings and underlying groundwater*. Is this correct? I thought I read the whole TSF would be underlain by liner?
4-24		*Leachate Recovered*. This refers to only the leachate collected from the dam face?
4-26		Water management. This is confusing. Collect precipitation for processing, yet divert upstream waters around the mine and not use? Where are the leachate recovery wells and are they just a safeguard?
4-28		Significant figures on precipitation estimates? What is the ET and how calculated?
4-31	3	…….*the mine pit would take approximately 100 to 300 years to fill*. From groundwater inflow only? Why such a large range of the estimate?
4-50	3	This peak flow calculation and discussion is confusing and needs clarification.
4-52		What is the recurrence interval of the 356mm?
4-60	4	Why a geometric mean using 3 values?

Page	Paragraph or Line #	Comment or Question
5-10		Definition of *highest reported index spawner*
5-20	1	*....salmon abundance related to pool size....and beaver ponds provide particularly large pools*. Are data available to characterize the stream type? Are beaver present?
5-22	2	*Assuming that no natural flow or uncontrolled runoff would be generated from the mine footprint*...All precipitation is intercepted? Or does this refer to the subsurface streamflow generation mechanisms?
5-23		It appears that the mean annual unit runoff is calculated incorrectly.
5-24		Table shows flow returned from footprint? Does not fit with page 5-22.
5-29	2	Groundwater-surface water connectivity. Are data available to show this connection throughout the watersheds or does the groundwater only return to the hyporheic in the low gradient areas? Similarly, where are the temperature data that suggest the lake and groundwater connection or this reference by incorporation?
5-32-39		The tables and hydrographs illustrating the potential flow changes are difficult to appreciate or interpret. Another means of presentation?
5-41	1	The value of 0.15km affected by the maximum mine size is questioned.
5-52	Table 5-17	Can we see summary stats on water quality, not just means? Plot of concentrations with streamflow?
5-55		*These effluent specific values are higher than those for background surface water because of the higher content of mineral ions*. This sentence needs clarification.
6-6	Table 6-1	Last line. What is the +/- value after the mean?
6-13	3	*...an intense local storm*.....Why use the Type 1a distribution for precipitation distribution?